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SUMMARY REPORT FOR NASA GRANT # NSG 2057,
FAR-INFRARED ASTRONOMY WITH THE KUIPER AIRBORNE
OBSERVATORY

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This report summarizes work made possible by NASA's Kuiper Airborne Observatory. The results of the work have appeared in over 80 papers (see attached list). The publications fall in three main areas: instrumentation, observations, and analysis. Although there is considerable overlap between these categories it will be convenient to group them separately.

1) Instrumentation

The first work under the grant was the introduction of non-imaging optics into far-infrared astronomy. The result was a significant improvement of the coupling of the incoming radiation to the detectors at the focal plane. To implement this type of optics it was necessary to develop designs for the light collectors, filters, and detector cavities. A succession of photometers incorporating the new optical techniques provided data not only for the Chicago group but also for many guest observers.

The next major effort was the development of instrumentation for far-infrared polarimetry. The basic design principle was to eliminate the effects of atmospheric fluctuations by simultaneous detection of two components of polarization. To apply the principle it was necessary to develop polarizing beam splitters, schemes for rotating the plane of polarization, and schemes to identify and remove systematic errors.

The polarimeters were then expanded to introduce detector arrays. This expansion required considerable redesign and revised techniques for removing the polarizing effects of the telescope and instrument. Like the photometers, the polarimeters have been used by ourselves and by many guest observers.

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2) Observations

The first major application of the photometers was the determination of the far-infrared emissivity of interstellar dust. This made it possible to estimate the masses of interstellar clouds on the basis of the thermal emission (see item 3 below). Another important application resulted in the first detection of thermal emission from a Bok Globule and the subsequent discovery of embedded low-mass sources in several globules. Concurrent observations showed the existence of multiple cores in several giant molecular clouds.

Observations with the polarimeters showed that measureable polarization can be found in most regions of typical molecular clouds. The magnetic fields inferred from the polarization maps are surprisingly orderly and thus susceptible to theoretical analysis. There are examples of magnetically controlled star formation, of a toroidal field in the circumnuclear dust ring, of longitudinal fields in filaments, and of magnetic arcs around expanding shells of ionized material.

An archive of all airborne polarimetry is being prepared for publication in ApJ Supplements.

3) Reviews

Among various review papers we mention those in four main areas of research:

a) The early photometric work is summarized in a paper (Hildebrand 1983) reviewing the principles and techniques for measuring dust emissivities and thereby estimating cloud and dust masses.

b) The basic techniques used in both the photometers and the polarimeters are discussed in a paper on focal plane optics for far-infrared and submillimeter astronomy (Hildebrand 1986).

c) The principles governing polarized emission are presented in a paper on the interaction of magnetic fields and interstellar dust (Hildebrand 1988).

d) A model for “heterogeneous” molecular cloud envelopes is offered in a paper presenting the first results of spectropolarimetry in the far-infrared and submillimeter regions of the spectrum. This paper presents a review of the principles governing polarization spectra at long wavelengths (Hildebrand et al. 1998).

One result of the work under this grant has been to provide techniques and research objectives that can be pursued with SOFIA, NASA’s next airborne observatory.

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